Pressure Distribution Guidance

MassDEP/MHOA Seminar
DATE

SPEAKER
Department of Environmental Protection

Pressure Distribution Guidance

- Updated Guidance published in May 2002
  - Originally issued in 1995
  - Developed by committee of health agents, private consultants, equipment suppliers and MassDEP staff
- Reflects experience gained since 1995

Pressure Distribution

- Promotes uniform distribution throughout the SAS
- Uniform distribution promotes proper treatment
- Effectiveness depends upon:
  - Proper design
  - Proper construction
  - Proper maintenance

Regulatory Considerations 310 CMR 15.254

- Example 1:
  - A single system serving a single facility is designed for a flow of 2,001 gpd.
  - Is pressure distribution required?
  - YES!

Regulatory Considerations 310 CMR 15.254

- Example 2:
  - A single facility with a series of seven systems each with a design flow of 330 gpd.
  - Is pressure distribution required?
  - YES!
  - WHY?
    - The aggregate flow from the facility is greater than 2,000 gpd (total flow = 2,310 gpd).

Exception to the Regulatory Considerations

Patented Sand Filter Systems*

- *Standard Conditions for Alternative Soil Absorption Systems with General Use Certification and/or Approved for Remedial Use*, February 3,2016
- II. Design and Installation Requirements, Paragraph 10, states Specific Conditions for Treatment with Disposal Alt. SAS Technologies

* If the applicant requests LUA for percolation testing (sieve analysis), use of a patented sand filter is not permitted if the soils are compacted or are Class III or Class IV – see MassDEP's May 3, 2006 Title 5 Alternative to Percolation Testing Guidance for System Upgrades

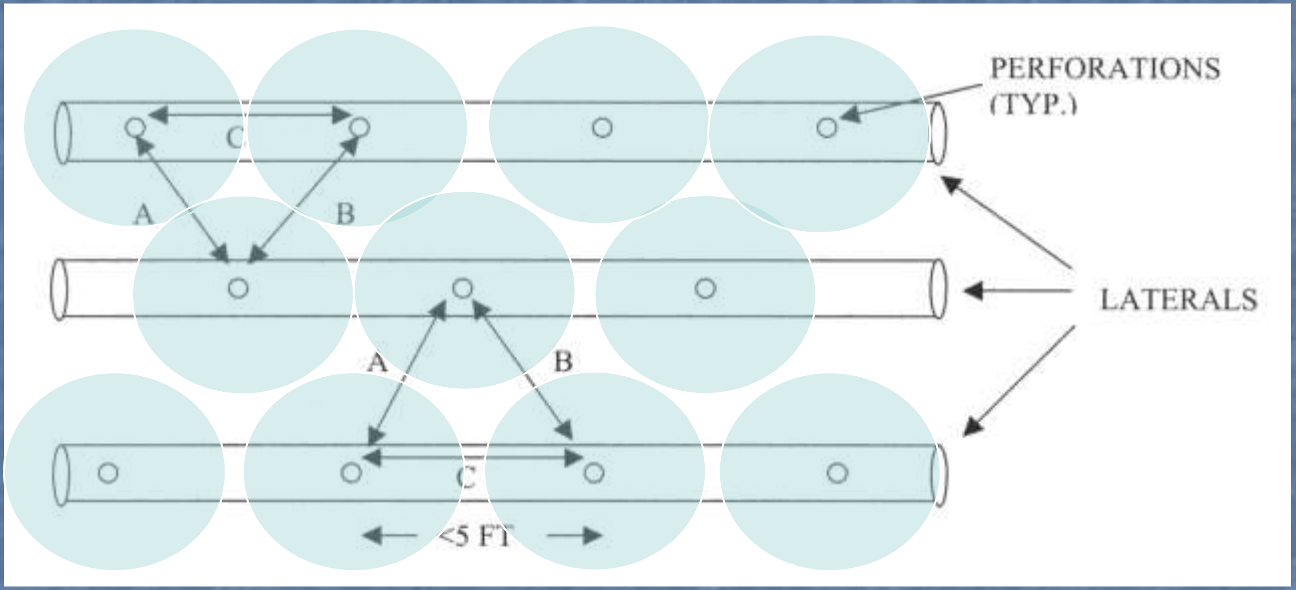
What Happened in 2002?

2002	1995
1/8" minimum perforation	¼" minimum perforations
Perforations orientated up or down with shield	Perforations at 5 and 7 o'clock – no shields
Lateral cleanouts (recommended)	Lateral cleanouts not mentioned
Greater number of diagrams and design samples	Minimum number of diagrams and design samples

Design Considerations

- In-line pressure:
  - 2.5 feet of head at distal lateral
  - Maximum 10% flow variation in system
- Perforations:
  - 1/8” minimum
  - Uniformly spaced – as many as practical
  - Stagger in bed formation

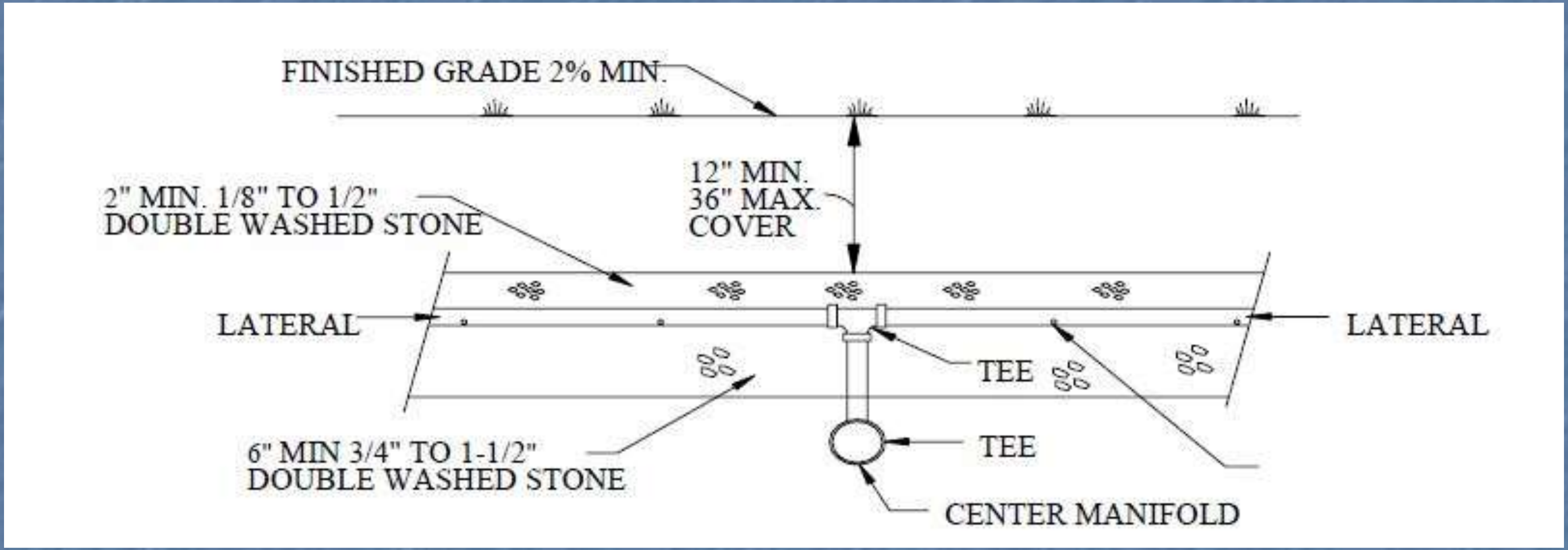
Staggered Perforations



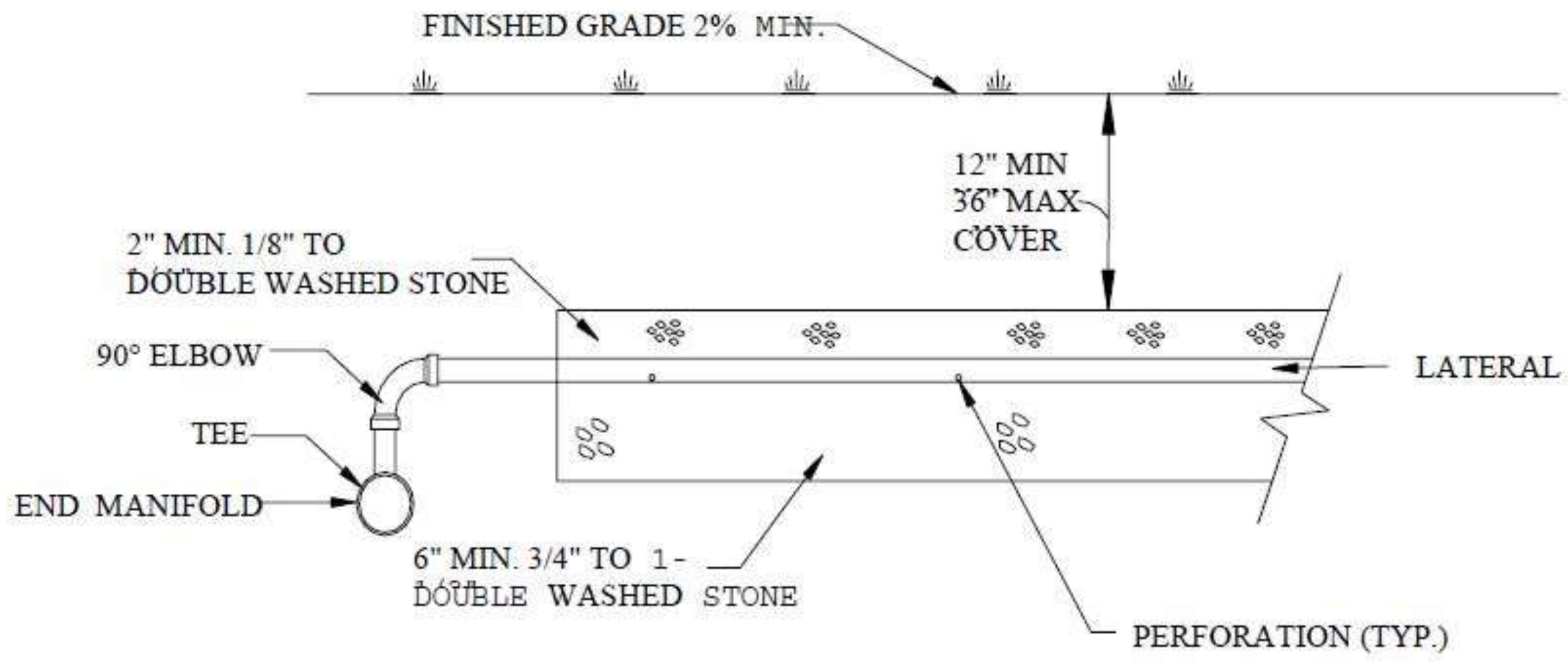
Manifolds

- Central or end configuration
- Minimize volume
- Install below distribution laterals

Center Manifold



Side Manifold



DESIGN PROCEDURES

Step 1: Lay Out a Network

- Design is based on site condition, flow rate and soil conditions
- Trench or bed configuration
- Central or end manifold – central minimizes lateral length
- Provide drainage of laterals

Step 2: Select Perforation Size and Spacing

- 1/8" to 5/8" perforations
  1. Smaller allow more uniform distribution
  2. Larger allow greater spacing and longer laterals – but can cause ponding
- Air must be vented
- Laterals must drain to SAS or pump chamber
- Spacing shall not exceed 5 feet

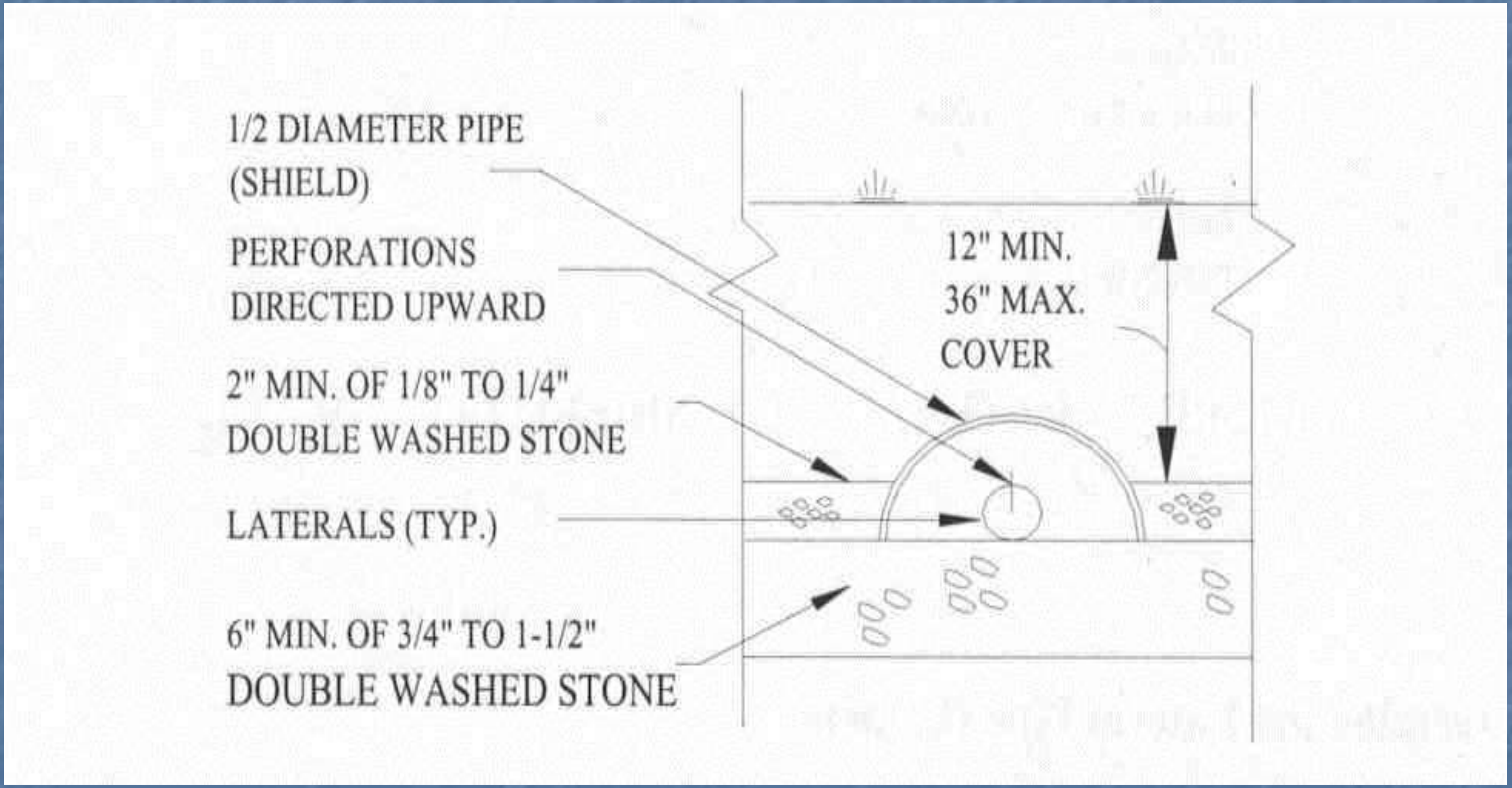
Step 2 – Continued perforation orientation

- Between 10 and 2 o’clock or 5 and 7 o’clock
- At 12 o’clock or 6 o’clock
- Shields are required for between 10 and 2 or at 6 to reduce scouring
- Shields can be half pipe, manufactured orifice shields, chambers, etc.

Shields

Courtesy Clarus Equipment, A Zoeller Family Company

Detail of Pressure Distribution with Shields



Step 3: Determine lateral pipe diameter

- Figures 8A – 8G in Appendix B of Guidance – R. Otis based on Hazen-Williams Equation
  - Based on C = 150
    - Perforation size and number
    - Spacing
    - Lateral length
- Accounts for maximum 10% head loss

Hazen-Williams Equation

$$h = 0.2083\ (100 / c)^{1.852}\ q^{1.852} / d_h^{4.8655}$$

where

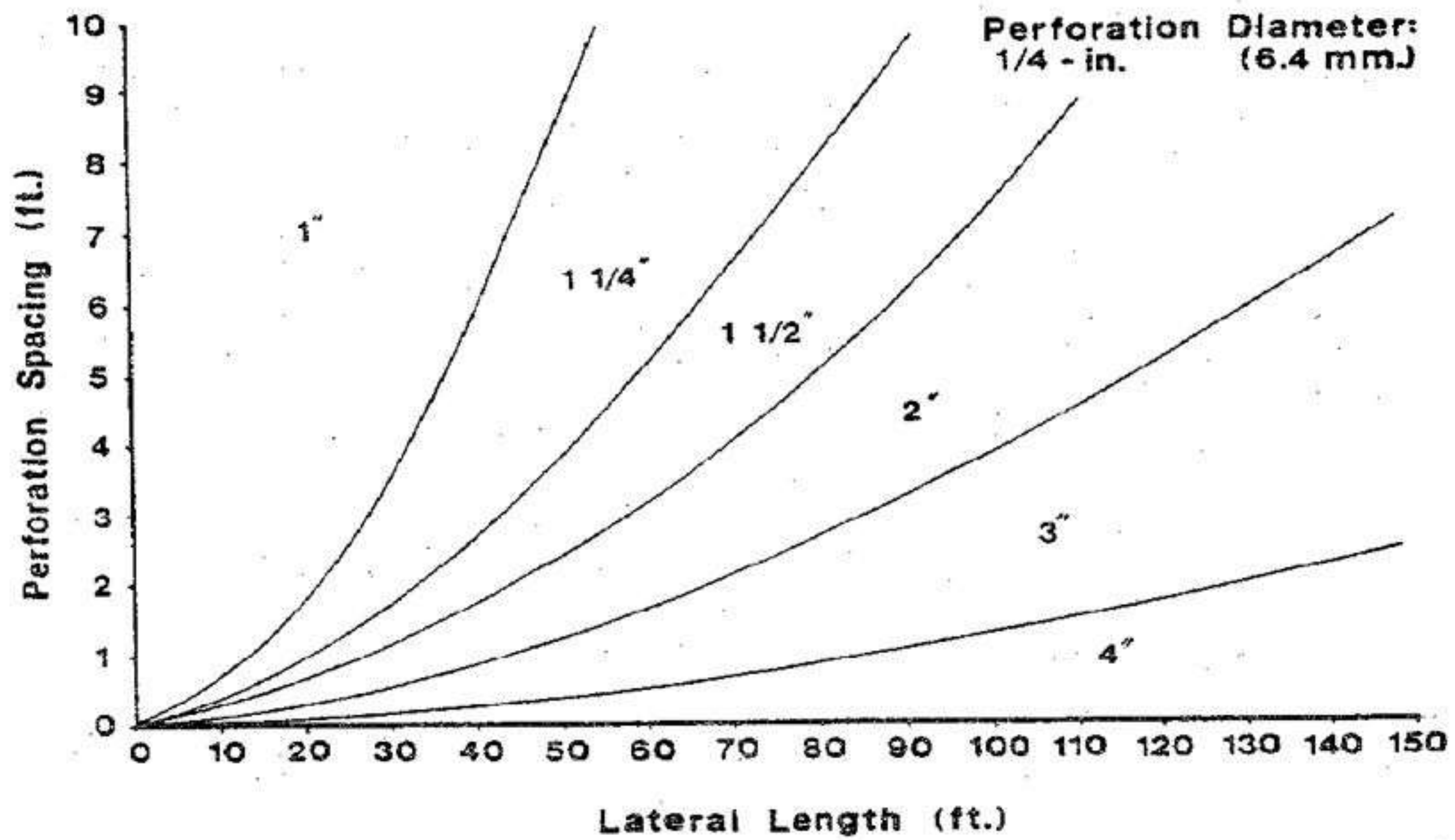
h = friction head loss in feet of water per 100 feet of pipe (ft_{H2O}/100 ft pipe)

c = Hazen-Williams roughness constant

q = volume flow (gal/min)

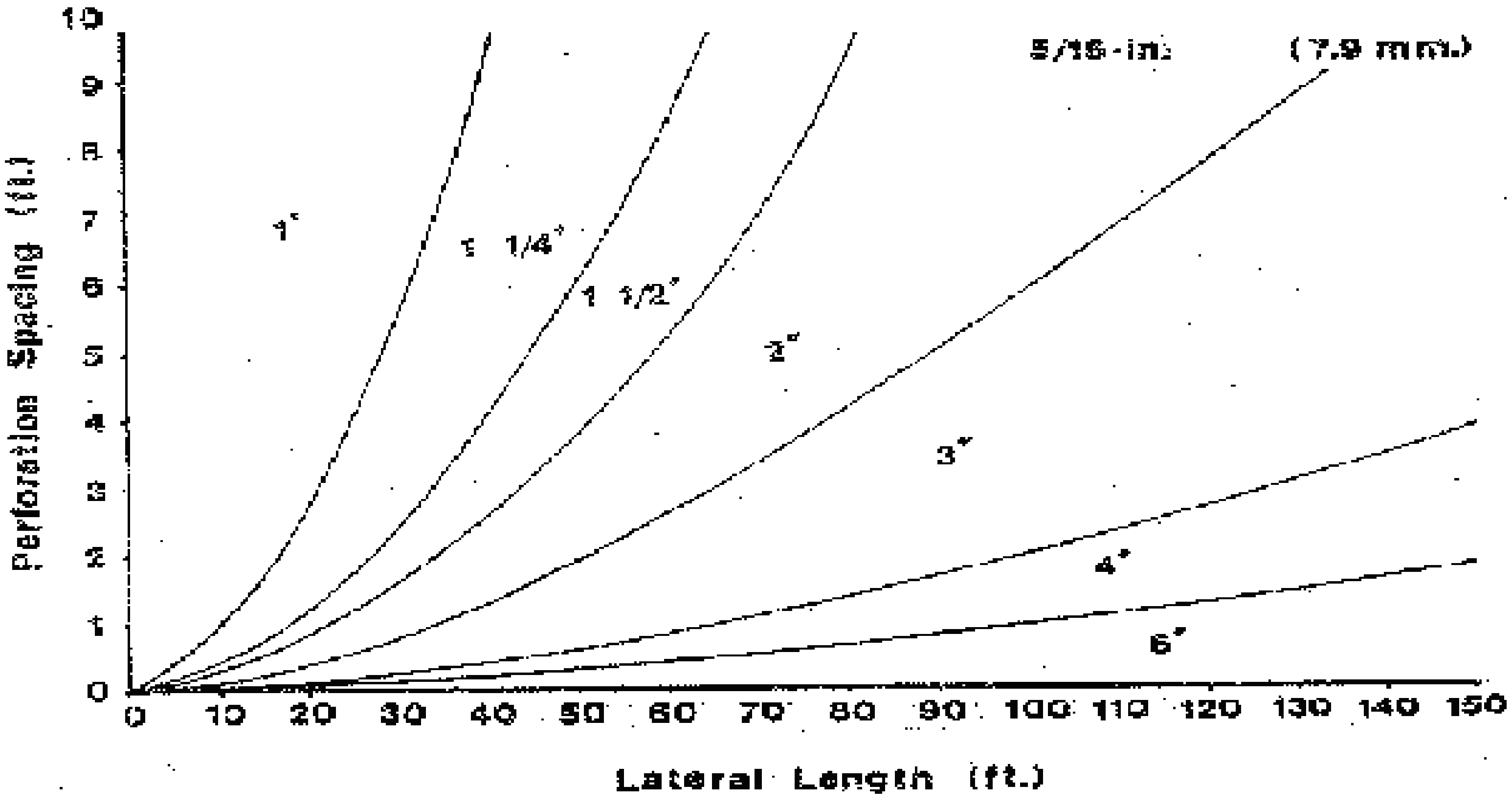
d_h = inside hydraulic diameter (inches)

Design Procedure



Minimum Lateral Diameter for Plastic Pipe (C_h = 150) Versus Perforation Spacing and Lateral Length for 1/4 in. Diameter Perforations (Otis, 1981)

Design Procedure



Minimum Lateral Diameter for Plastic Pipe (C_h = 150) Versus Perforation Spacing and Lateral Length for 5/16 in. Diameter Perforations (Otis, 1981)

Step 4: Calculate the Lateral Discharge Rate

$$q = 11.79\, d^2\, h_d^{0.5}$$

q: perforation discharge rate (gpm)

d: perforation diameter (inches)

h_d: in-line distal pressure (feet)

Use Table 1 in Guidance

Minimum distal head pressure = 2.5 feet

Total discharge: q x N

N: total perforations in lateral

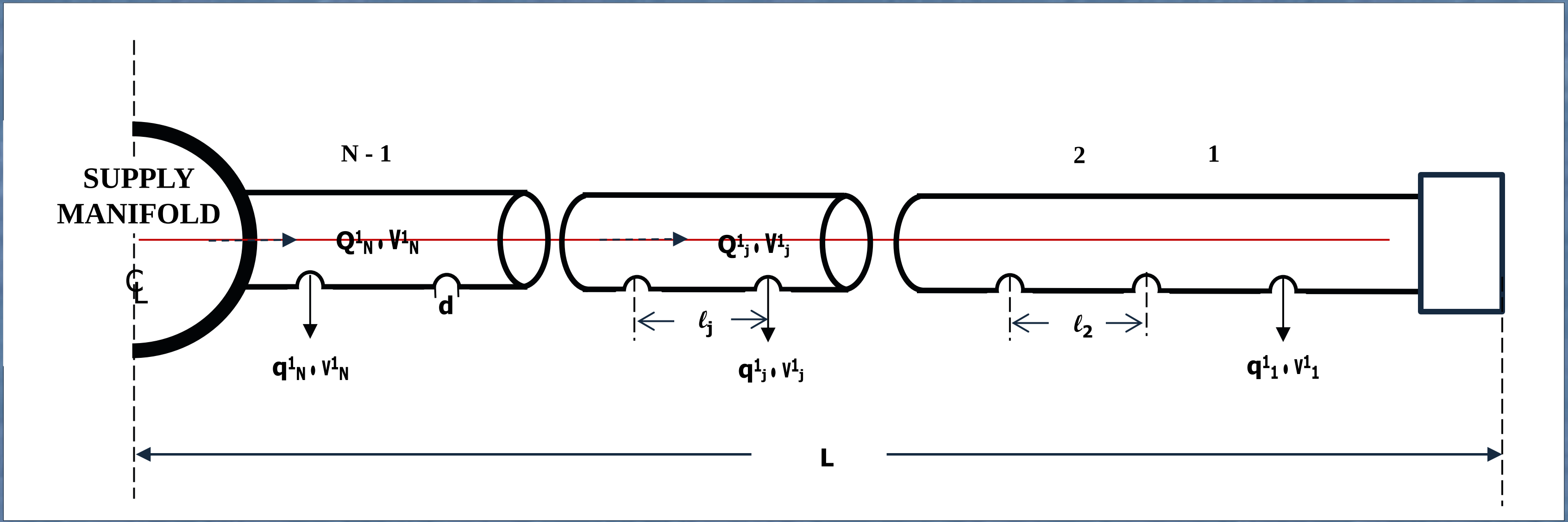
Table 1

Perforation Discharge Rates in Gallons per Minute vs. Perforation Diameter and In-Line Pressure (adapted from Otis, 1981)

In-Line Pressure (ft)	Perforation Diameter (inches) 1/8	1/4	5/16	3/8	7/16	1/2	9/16	5/8
	gpm							
1.0	0.18	0.74	1.15	1.66	2.26	2.95	3.73	4.60
1.5	0.22	0.90	1.41	2.03	2.76	3.61	4.57	5.64
2.0	0.26	1.04	1.63	2.34	3.19	4.17	5.27	6.51
2.5	0.29	1.17	1.82	2.62	3.57	4.66	5.90	7.28
3.0	0.32	1.28	1.99	2.87	3.91	5.10	6.46	7.97
3.5	0.34	1.38	2.15	3.10	4.22	5.51	6.98	8.61
4.0	0.37	1.47	2.30	3.31	4.51	5.89	7.46	9.21
4.5	0.39	1.56	2.44	3.52	4.79	6.25	7.91	9.77
5.0	0.41	1.65	2.57	3.71	5.04	6.59	8.34	10.29

NOTE: Figures for 1/8 inch perforation diameters compiled by P. Spath, B. Dudley, (2001)

Definition Sketch



Where:

N: the number of perforations
Q^1_j: Total flow through the lateral segment
V^1_j: Velocity though the lateral segment
q^1_j: Flow though a particular orifice specified by the subscript
v^1_j: velocity through a particular orifice specified by the subscript
ℓ_j: the length of an segment between orifices
L: the total length of the lateral

Step 5: Calculate Manifold Size

- In larger systems telescoping manifolds can reduce friction loss
- Determine friction factors:

$$F_i = (9.8 \times 10^{-4})Q_i^{1.85}$$

  - F_i: friction factor for manifold segments
  - 0.00098: coefficient of friction for plastic pipe
  - Q_i: flow in manifold segment (gpm)

Step 5: Calculate Manifold Size continued

- Take the Fi values in each lateral segment
- Calculate pipe segment diameter

$$D_m = \left[\frac{\sum_{i=l}^{M} L_i F_i}{f\, h_d} \right]^{0.21}$$

Manifold Diameter Calculation

$$D_m = \left[\frac{\sum_{i=1}^{M} L_i F_i}{f\, h_d} \right]^{0.21}$$

- M = no. of segments
- L_i = length of i^{th} segment (lat'l spacing)
- f= fraction of total head loss (0.1) so limited to 10%
- h_d=distal head (ft)

Steps 6 and 7

- Step 6: Determine dose volume
  - Minimum **5 to 10** times volume of laterals
  - Do not include manifold vol. if below laterals
  - Necessary to properly charge the system
- Step 7: Calculate min. pump discharge
  - Add all perforation discharge rates

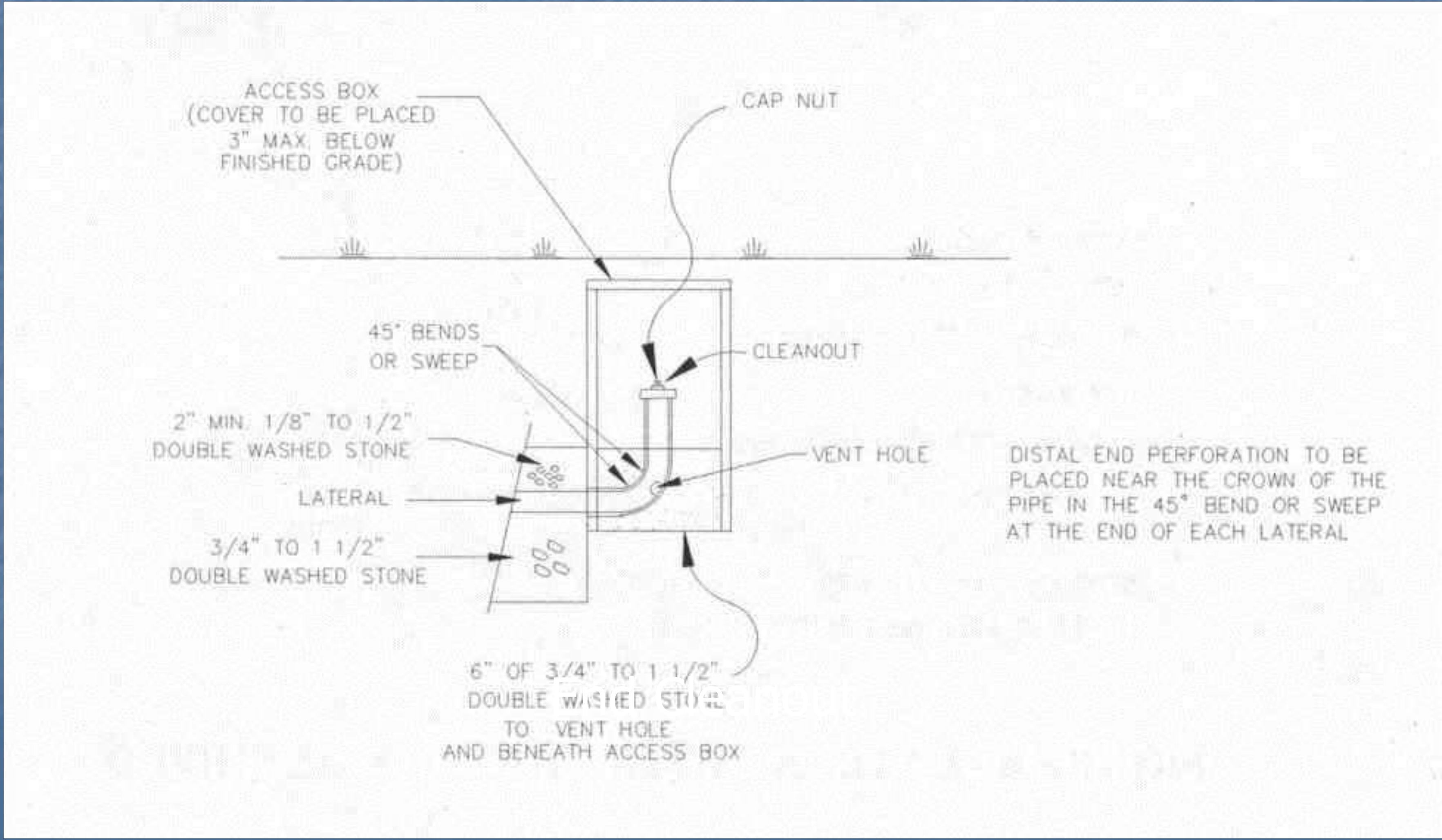
Step 8: Calculate Total Friction Losses

- Force main:

  Friction loss = $L_d(3.55Q_m/C_hD_d^{2.63})^{1.85}$

  - Ld: length of force main to network inlet (feet)
  - 3.55: dimensionless coefficient for energy loss
  - Q_m: discharge rate (gpm)
  - C_h: 150 (Hazen-Williams)
  - D_d: force main diameter (inches)
- Add network losses (1.31 h_d)
- Add fixture losses (tees, bends, valves etc.)

Design Procedure



Step 9: Select the Pump Unit

- Follow standard engineering practice
- Sized on total dynamic head (TDH)
  - Static losses
  - Friction losses
  - Network losses
- Use appropriate pump curves

Step 10: Size the pump chamber

- Discharge design dose
- Provide emergency storage capacity above high water alarm
- Include pump on/pump off and alarm
  - Pump on/off for single pump
  - Lead/lag on/off for dual pumps
  - Alarm on separate power circuit from pump(s)
- Quick disconnect
- Siphon break if pump downhill

Design Alternatives

- Divide SAS into zones – must dose all zones before returning to the first
- Timed dosing is an option
  - More applicable to larger flows
  - Must have certain overrides to prevent under or over dosing

Construction Considerations

- Debur all perforations
- Use effluent tees in the septic tank to help prevent solids carry over (not necessary if treatment unit precedes discharge)
- Lay out laterals in proper orientation and position
- Provide sweeps for cleanout
- Clear water test prior to backfilling

REGIONAL CONTACT

NAME

Telephone number

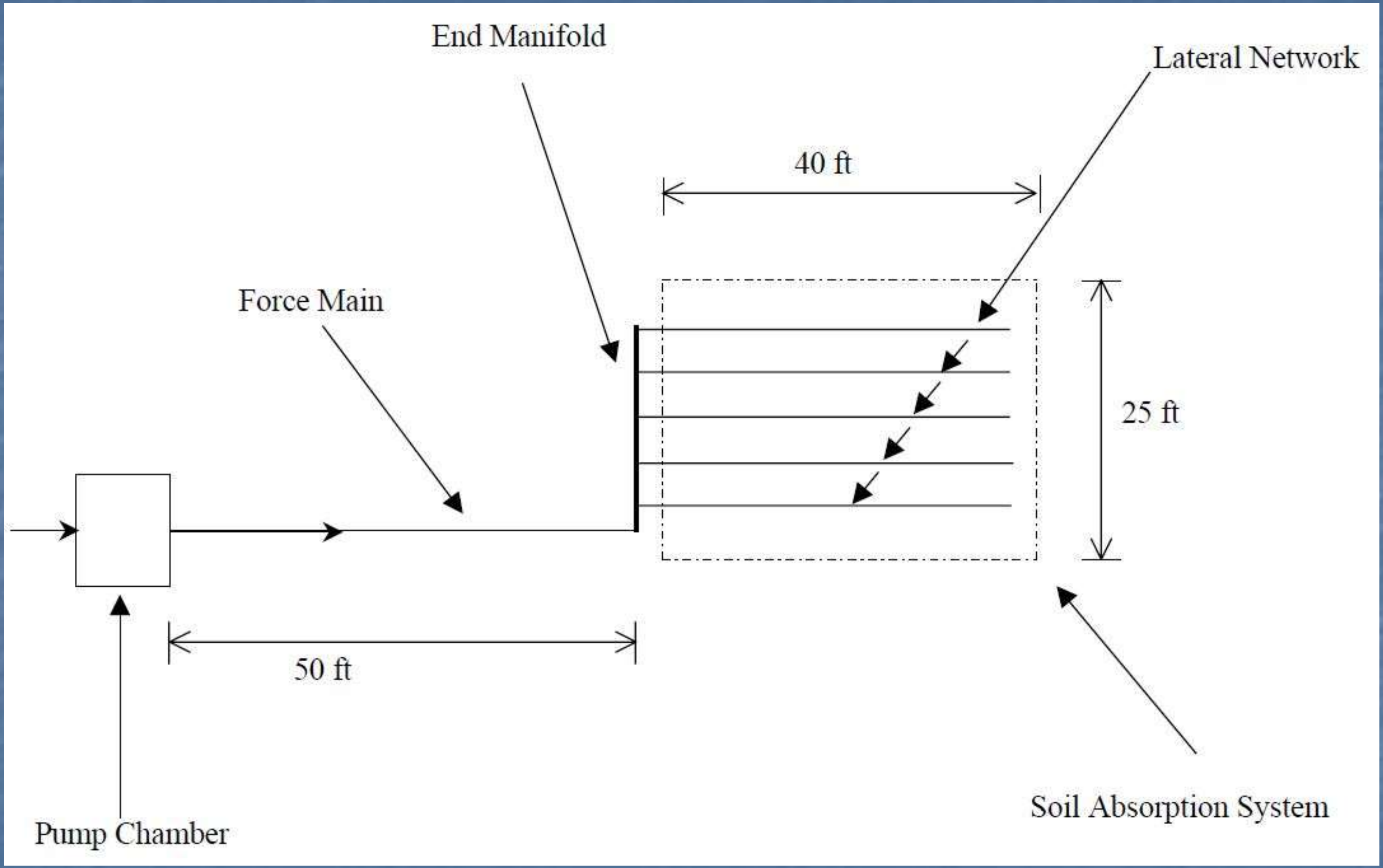
Email address

Any questions before we start some examples…

Design Examples

Scenario 1

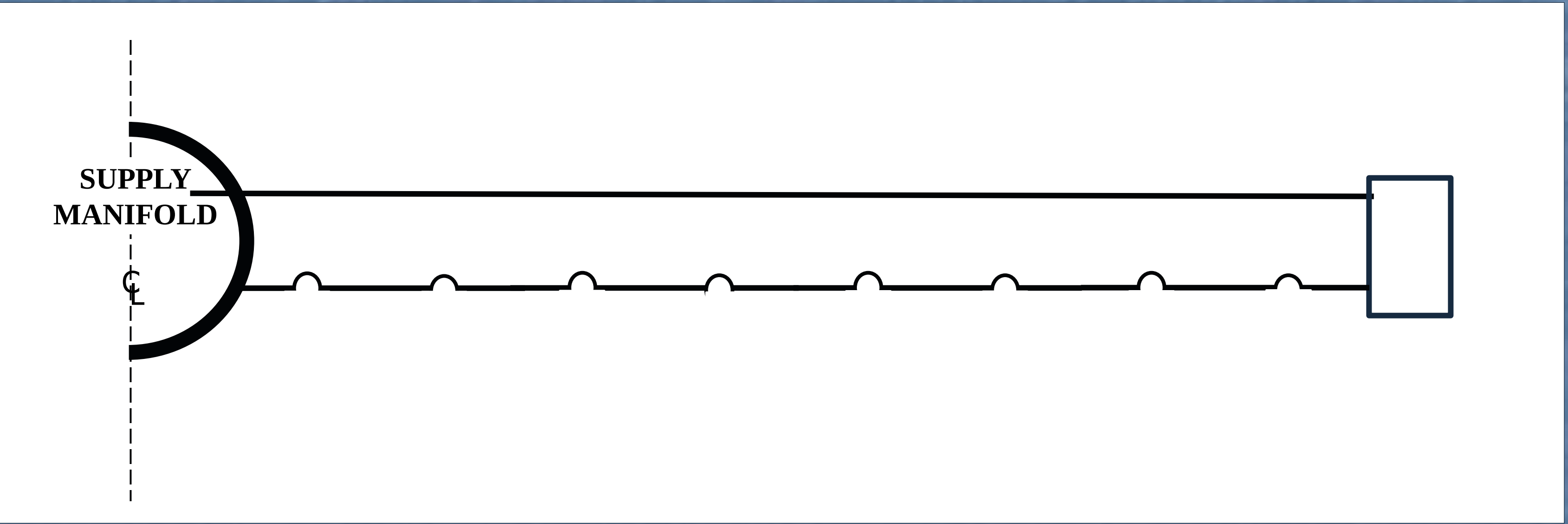
- Single family home
- 6 bedrooms (no garbage grinder)
- 660 gpd
- Class 1 soils with 8 mpi perc
- Resulting LTAR is 0.66 gpd/sf


End Manifold
Lateral Network
40 ft
Force Main
25 ft
50 ft
Soil Absorption System
Pump Chamber

Steps 1 and 2

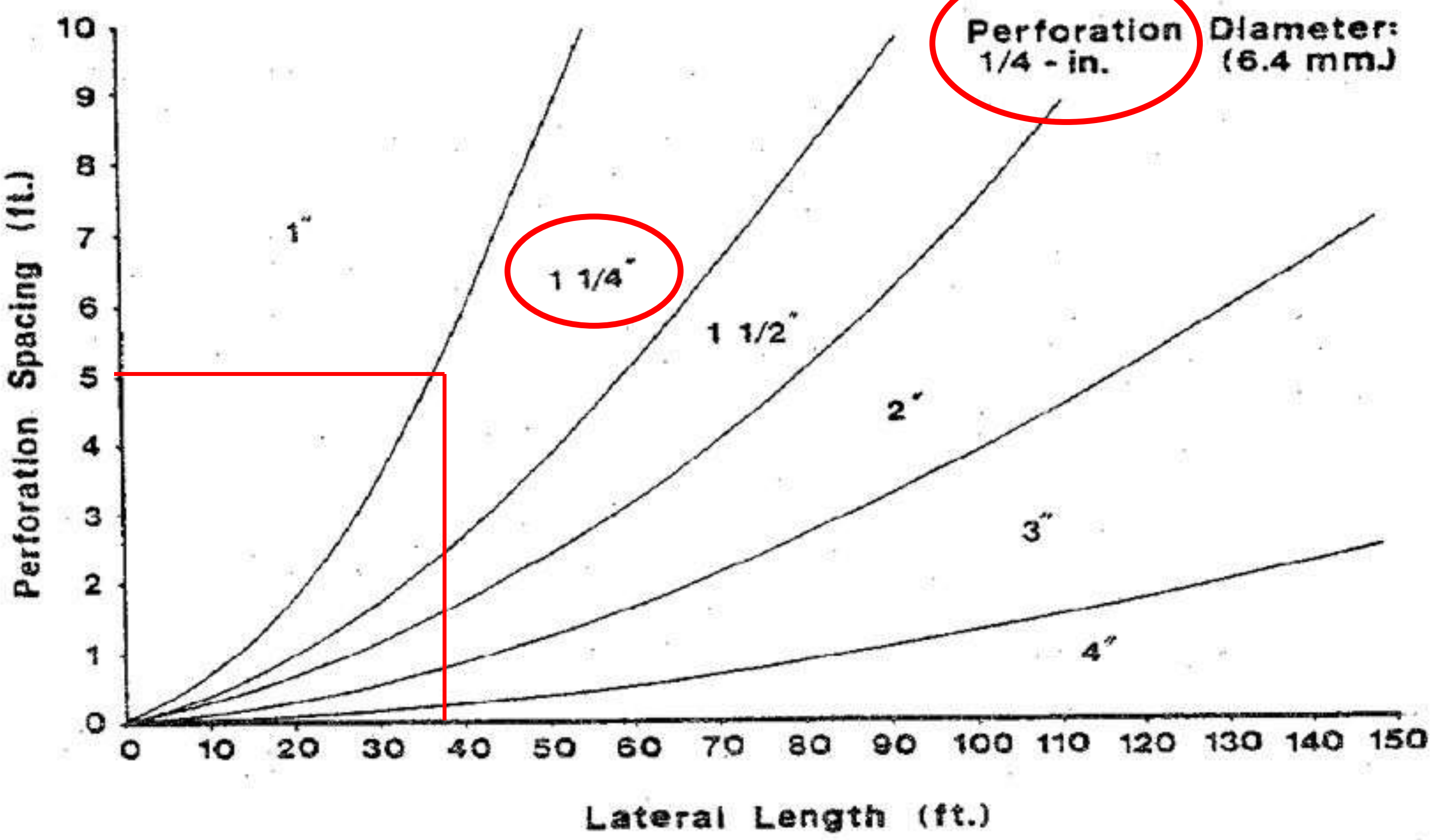
- Lay out the network
  - End manifold
  - 5 laterals
  - Pump chamber is 50 feet from the manifold
  - SAS is 40 ft long by 25 feet wide
- Select perforations size and spacing
  - 1/4 inch diameter perforations
  - Maximum spacing of 5 feet

Step 3: Lateral Diameter



Lateral length:
1st and last perforations in the lateral are located ½ the distance of 5 feet.
Therefore the distance from the first orifice to last orifice is reduced by ½ the spacing: 40 ft – (0.5 * 5 ft) = 37.5 ft
This becomes the lateral length you use.

Step 3: Lateral Diameter



Minimum Lateral Diameter for Plastic Pipe (C_h = 150) Versus Perforation Spacing and Lateral Length for 1/4 in. Diameter Perforations (Otis, 1981)

Step 4: Calculate Lateral Discharge Rate

Using Table 1 with a minimum in-line pressure of 2.5 ft to determine discharge from a 1/4 inch perforation

Table 1

Perforation Discharge Rates in Gallons per Minute vs. Perforation Diameter and In-Line Pressure (adapted from Otis, 1981)

In-Line Pressure (ft)	Perforation Diameter (inches)							
	1/8	1/4	5/16	3/8	7/16	1/2	9/16	5/8
	gpm							
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NOTE: Figures for 1/8 inch perforation diameters compiled by P. Spath, B. Dudley, (2001)

Step 5: Calculate the Manifold Size

- Uniform diameter (simplify construction)
- Manifold Length = 4 * 5 ft = 20 ft
- Use Table 2 for an end manifold with a lateral discharge rate of 9.36 gpm and 5 ft lateral spacing
- The best fit appears to be either:
  - 20-foot long 2 inch manifold; or
  - 44-foot long 3 inch manifold

Lateral Discharge Rate

- 1.17 gpm discharge per orifice
- Total length of lateral is 40 feet
- Orifice spacing is 5 feet with the first orifice 2.5 feet from the lateral start and the last orifice 2.5 feet from the end
- No. of orifices = 40/5 = 8
- Discharge rate = 8 orifices * 1.17 gpm/orifice = 9.4 gpm

Table 2

Maximum Manifold Length (ft) For Various Manifold Diameters Given the Lateral Discharge Rate and Lateral Spacing (from: Otis, 1981)

Lateral Discharge Rate	Manifold Diameter = 1¼"	Manifold Diameter = 1 ½"	Manifold Diameter = 2"	Manifold Diameter = 3"	Manifold Diameter = 4"	Manifold Diameter = 5"
End Manifold / Center Manifold	Lateral Spacing (ft) 2 4 6 8 10	Lateral Spacing (ft) 2 4 6 8 10	Lateral Spacing (ft) 2 4 6 8 10	Lateral Spacing (ft) 2 4 6 8 10	Lateral Spacing (ft) 2 4 6 8 10	Lateral Spacing (ft) 2 4 6 8 10
10 / 5	4 8 6 8 10	10 8 12 16 20	12 16 24 24 30	26 40 48 56 70	42 64 84 96 110	84 134 174 200 240
20 / 10	4 4 6	4 4 6 8 10	6 8 12 16 20	16 24 30 32 40	26 40 54 64 70	54 84 106 128 150
30 / 15	2	2 4 6	4 8 6 8 10	12 16 24 24 30	20 26 36 48 60	42 64 84 96 110
40 / 20			4 4 6 8 10	10 12 18 16 20	16 24 30 32 40	34 52 66 80 90
50 / 25			2 4 6 8	8 12 12 16 20	14 20 24 32 40	30 44 60 72 80

Step 6: Determine Dose Volume

- Crown of manifold is below lateral invert
- Manifold and delivery line drain back.
- Minimum dose volume only in laterals
- 5-10 times the total lateral volume

Dose Volume Continued (2)

Total length of laterals: 5 pipes*40 ft = 200 ft

Area of 1-1/4 in (0.1042 ft) laterals:

$\pi r^2 = \pi*(0.0521)^2 = 0.0085$ sf

Total pipe volume

0.0085 sf * 200 ft = 1.7 cf

1.7 cf * 7.48 gal/cf = 12.7 gallons

Dose Volume Continued (3)

- Min dose volume of 5-10 times pipe volume
  - 12.7 gal (5 to 10) = 64 to 127 gal
- Dose frequency: 12 doses per day (dpd)
  - 660 gpd/6 dpd = 55 gal per dose
- Manifold and delivery line drain back must be accounted for. Both are 2-in pipes:
  - $(20+70)$ ft * π * $(0.0833)^2$ ft^2 = 1.52 ft^3
  - 1.52 ft^3 * 7.48 gal/ft^3 = 11.4 gal

Dose Volume Continued (4)

Pumping volume = dose volume + drain back volume

= 55 gal + 11.4 gal = 66.4 gal

Step 7: Calculate the Minimum Discharge Rate

Minimum discharge rate =

9.4 gpm/lateral * 5 laterals = 47 gpm

Step 8: Friction Loss Calculation

Friction loss = $L_d(3.55Q_m/C_h D_d^{2.63})^{1.85}$

- L_d: 50 ft (length of force main)
- 3.55: dimensionless coefficient for energy loss
- Q_m: 47 (gpm)
- C_h: 150 (Hazen-Williams)
- D_d: 2 inches

Friction loss =

$(50)((3.55*47)/(150*2^{2.63}))^{1.85} = 2.08$ ft

Network loss = $1.31h_d = 1.31*2.5$ ft = 3.28 ft

Total losses (not including pump chamber or fittings) = 5.36 ft (round up and use 6 ft)

Step 9: Select the Pump Unit

Total Head = Static Head + Friction Losses

If the pump off elevation in the pump chamber is 4 feet below the lateral invert, then the total head is

4 ft + 6 ft = 10 ft

Use head/discharge curves and find a pump capable of pumping 47 gpd against 10 feet of head

Step 10: Size the Pump Chamber

Only one pump will be used (< 2,000 gpd)

Reserve volume = one day's average daily flow

Pumping Volume	66.4
+ Daily Design Flow	660
	726.4 gallons